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(54) Data storage devices

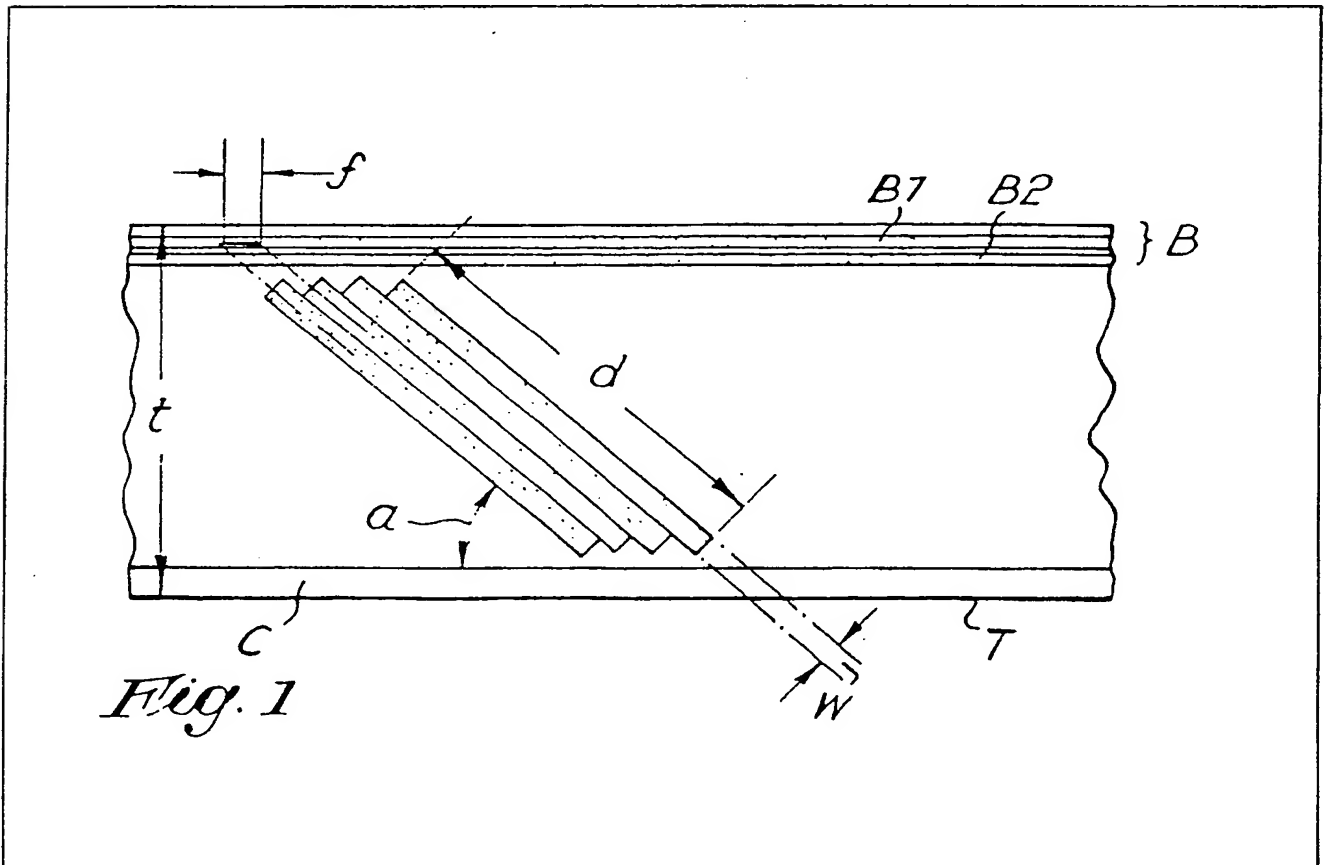
(57) To provide a data store in which a
data carrier (T) can hold a vast quantity

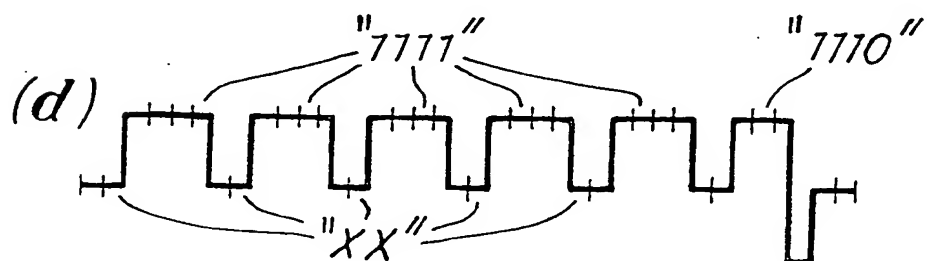
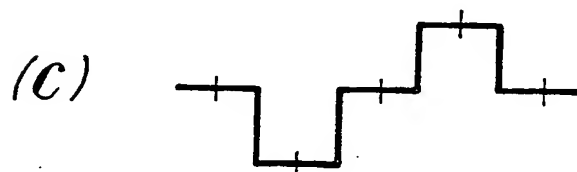
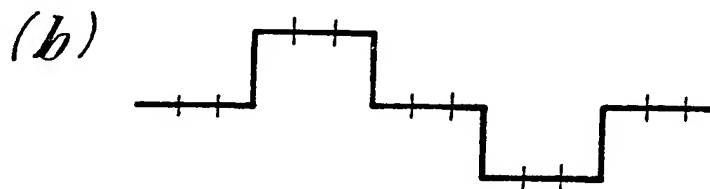
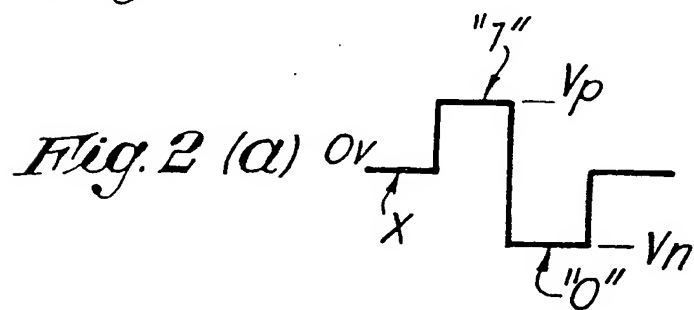
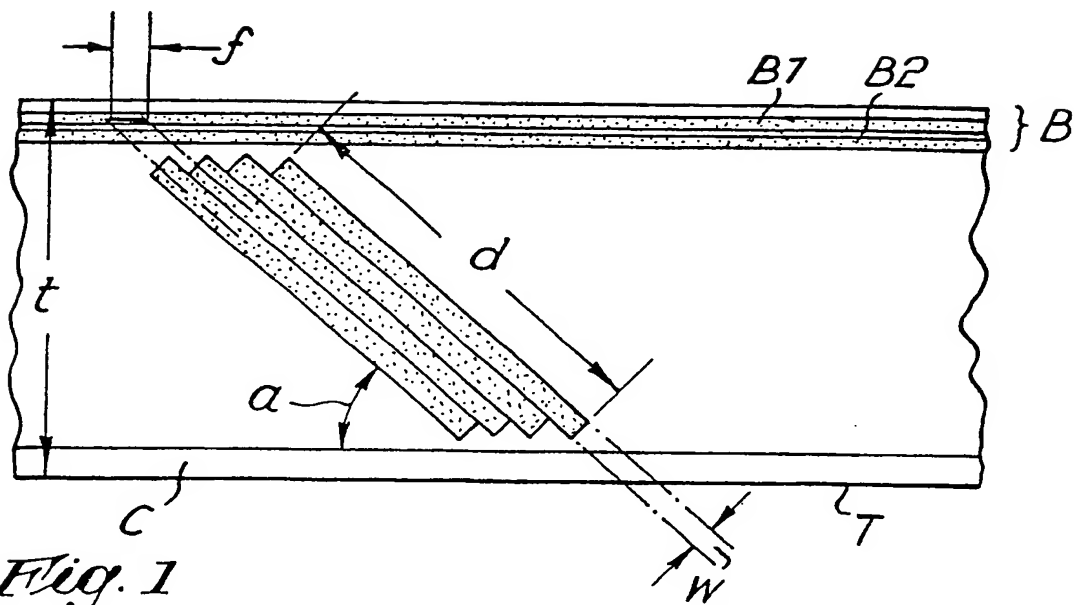
of data and give rapid access, a format
of slant tracks is used each starting with
a unique track identity number and one
or more longitudinal control tracks (B,C)
provide for high speed mode search,
and low speed mode location.

Coarse location of a required group of
tracks may be provided by coded signal
sequences on one track (B1) and indi-
vidual tracks identified by coded signal
sequences in a further longitudinal con-
trol track (B2). In the high speed mode
only the control track passes a reading
head. In the slow mode the carrier is
wound to half embrace a helical scanning
drum carrying a plurality of heads.

Read only devices may be provided
for use as a reference source in library
or computer installations possibly with
multi-user and/or multi-bus facilities.

Where required provision may be
included for recording and/or read-out
of stored data, but the control track
sequence is preferably pre-recorded
and constant.





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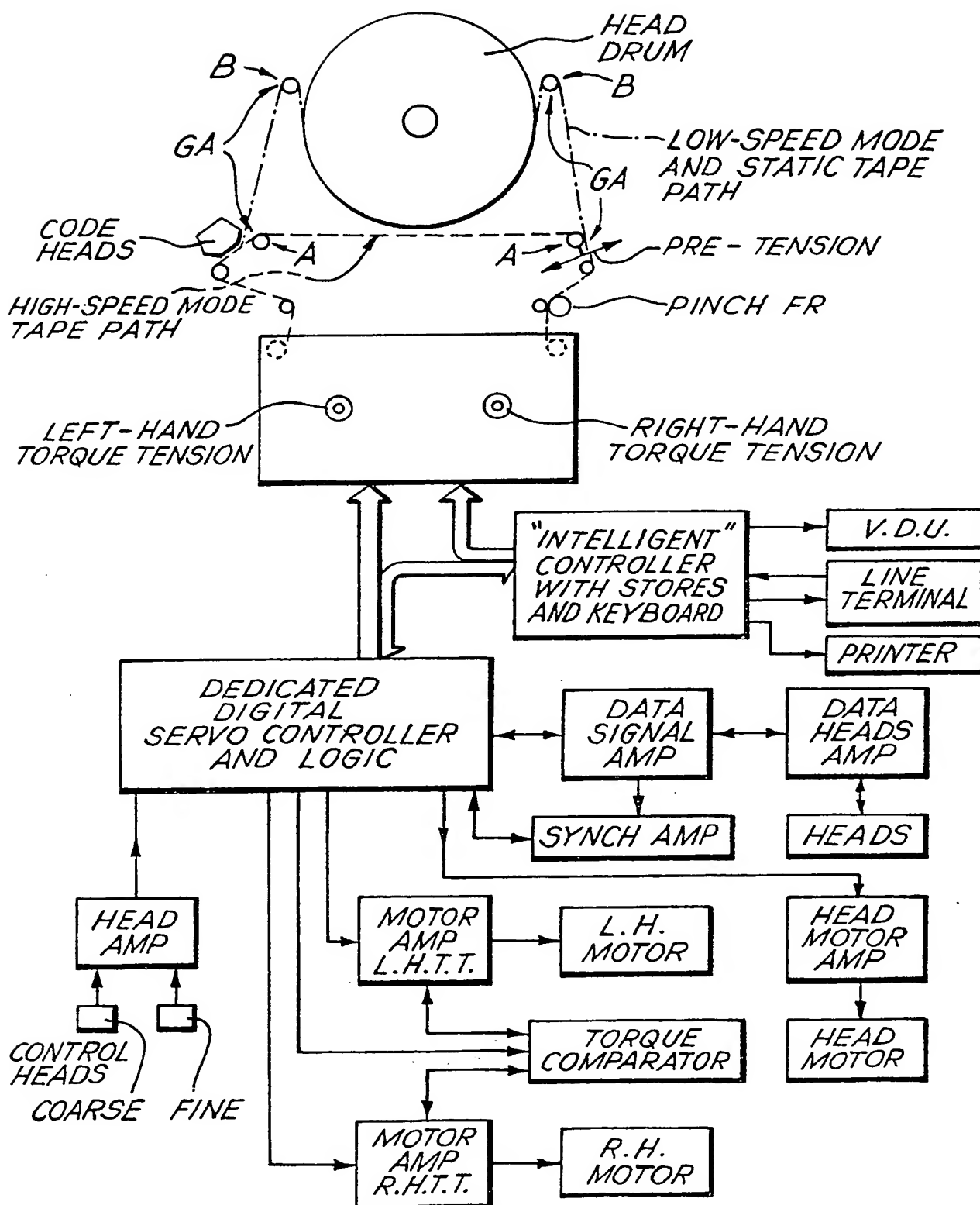
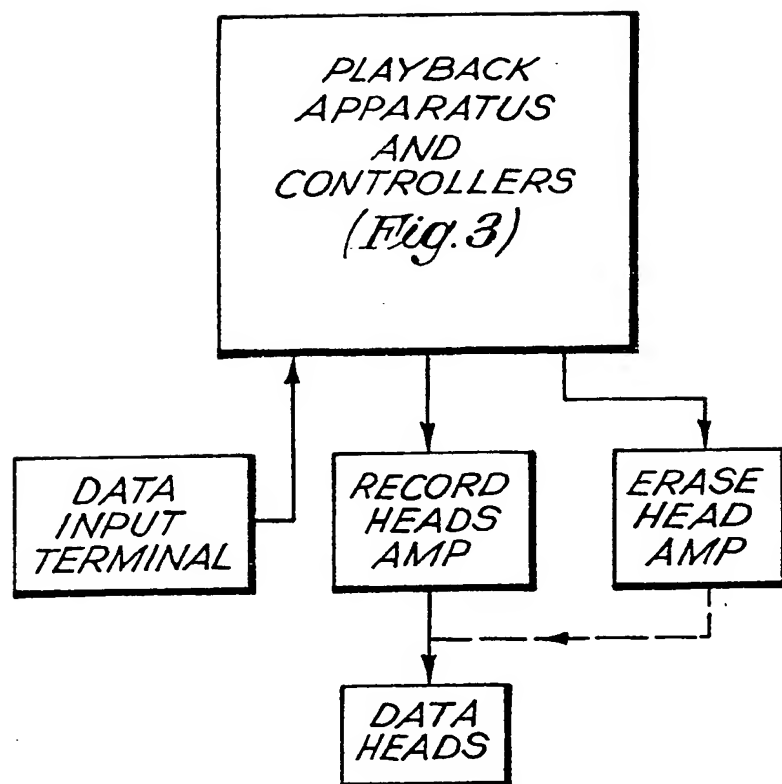


Fig. 3

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*Fig. 4*

SPECIFICATION

Data storage devices

5 The invention relates to data stores, and in particular to a novel form of data storage on a data carrier, to read-out apparatus for reading from such data carriers, and to data store recording devices providing for entering data on the carrier as required, and
10 performing selective read-out, erasure and recording.

Presently available data carriers for high-density storage comprise solid-state matrices of relatively limited capacity but rapid access, disc or drum
15 devices that give a considerably increased capacity, and only a slight access time delay, but at the expense of a considerable increase in financial outlay for mechanisms and circuitry of high complexity. Finally, there is the use of tape spools, which
20 can make a mammoth capacity available, but requires provision to be allowed for prolonged access time in some adverse conditions.

One object of the present invention is to so dispose data on a rectilinear carrier, such as a tape,
25 that a maximum packing density can be achieved without incurring the prolonged access time required for stores using large tape spools.

According to one exemplary embodiment of the present invention there is provided a data store in
30 which a rectilinear data carrier is provided with a control track along at least one edge and a plurality of inclined data storage tracks each extending to a respective point adjacent said control track across said data carrier, each said data storage track
35 carrying a signal sequence comprising a start code signal providing a unique track-identification code number, and any data recorded thereon, and in which said control track carries a sequence of said unique track-identification code signals in numerical
40 order, each preceded by a start-of-track signal and a code start signal, and each followed by an end-of-code signal and an end-of-track signal, the signals in said sequence on said control track being so recorded that they can be read-out by relative move-
45 ment of said control track with respect to a read-out head in either direction, and said start-of-frame signals either being aligned with the start of the related data storage track or spaced from that track by a predetermined distance in a predetermined
50 direction along said control track.

Advantageously the data-carrier is a flexible tape, preferably of magnetic material. The coded signals are conveniently recorded in a tri-phase code adapted to provide a plurality of error-checking
55 facilities.

The recorded data may be a video signal, possibly complete with a chroma signal if coloured images are being recorded, and each storage track preferably holds a complete field in this case.

60 Read-out apparatus for use with such a data store may comprise drive means provided to move said data carrier relative to a control track read-out head in such a manner that the signals on said control track are read-out, selection means being provided
65 to request that the data carrier is automatically

driven to a required data-storage track, logic means being provided to determine the direction of travel required to reach the required track, and drive means initially causing a relatively high-speed mode
70 if required, until further logic means detect the approach of the required track, whereupon a relatively slow-speed mode is initiated by the "start-of-track" signal at said control track read-out head, and said tape is caused to fold about and partly embrace
75 a rotating drum which carries a plurality of data read-out heads positioned to sweep along said required data-storage tracks, said drive means is caused to continue said movement in a relatively slow-speed mode until the required track-
80 identification code signal is read-out, when said tape is either held stationary with respect to said control-track read-out head, or moved by said drive means at a rate to bring the start of the succeeding data storage track into alignment at the end of sweep of
85 said required track.

A complete data recording device may be provided, in which the read-out apparatus is combined with erase and recording facilities.

The invention will now be described with reference to the drawings; in which:-

Figure 1 is a plan view of a fragmentary portion of a data carrier on which coded control signals and inclined tracks storing data are disposed in accordance with a preferred embodiment of the invention;

95 *Figure 2* is a set of explanatory waveforms illustrating details of a preferred tri-phase coding using unique combinations of error-checking pulses to indicate pre-determined code signal positions in addition to providing parity-checking safety-measures;

Figure 3 is a block schematic circuit diagram showing details of the mechanical features and circuitry of an exemplary playback apparatus; and

105 *Figure 4* is a block schematic circuit diagram showing details of an exemplary recording device complete with record, erase and selective re-recording features.

The layout of the data on the carrier is shown in *Figure 1*, and in general terms the configuration is of the conventional type used in helical scan recording. We will assume that the carrier is a magnetic tape housed in a cassette, although this is not essential to the underlying principals of the invention, and other materials and recording techniques could be used,
115 for example a thermal-writing laser could be used to record the data on a suitable material. Furthermore instead of a great length of tape wound from one reel to another, a relatively short length in the form of a flexible strip could be employed assuming that
120 an appropriate conveyor drive is provided to move the carrier with respect to the apparatus.

The carrier T has a control track B along its edge and a further control track C may be provided along the other edge of the carrier. When in use, the carrier
125 is stationary with respect to a rotatable "head-drum" about which the carrier T is wound for approximately 180° when in the data record or playback mode. The fast rotation of the rotatable "head-drum" will lead to the writing of a slanting or inclined track that
130 has an angle α with respect to the longitudinal axis of

the carrier. If we assume that the tape is held stationary during data recording or replay, and the the head-drum is rotating so as to carry a recording head along the inclined track without tracking error,

5 correct synchronisation has been established by a synch-pulse recorded at a position dictated by the control track signal sequence. It will be appreciated that the slant action is produced because the tape is wound on a helical path about the head-drum, and

10 the head itself does not in fact move off of its circular path. The length of the recording on a single track, and the amount of data that can be recorded thereon is determined by the duration d and in equipment based upon video recording equipment this will be

15 the duration of one field, i.e. a period less than one fiftieth of a second. Obviously, the actual duration available will depend upon the width of the tape the speed of rotation and overall diameter of the head-drum, and the aperture of the recording head. The

20 important point to be considered is the need to locate a particular track if selected data is to be readily available, whether it be a television video field, of the data store of a computer, or map or typescript displays, all of which can be readily

25 converted into the signal to be laid down upon a single track. In order to locate the individual tracks the carrier T is provided with a specific track identification signal for each track recorded thereon. This must be laid upon the control track and may be

30 the control track B or the control track C. In a typical case these tracks will have a width of from 0.75 mm to 1mm. It is necessary to ensure that the duration between the portion of control track aligned with the beginning of one data track and the beginning of the

35 next data track, which has a length f in the illustration shown in Figure 1, has to accommodate sufficient coded data to identify each given track and mark the position of the beginning of the track with reference to a control track reading head which is a

40 known distance on the control track path from the beginning of the indicated data track. It is possible to conceive of a configuration which would permit a single control track signal containing a sequence of the individual identification codes, but because of

45 the physical arrangement of the tape and the need for high speed search it might be most inconvenient to attempt to arrange for such a facility. Therefore in a preferred embodiment a first track identification code signal is recorded as one path along a control

50 track B1, and this contains a group identification code for a group of data tracks, and a typical case would be for each group to contain one hundred tracks. As a modification of the normal high speed mode or re-wind action, the invention would be to

55 have the control head in contact with the control track during the high speed winding action and the process control apparatus would search for the required group identification. As will be described later with reference to the apparatus the intention is

60 that when the group identification signal is located, or when the track identification code is approaching, in the case where a single control code track is used, the machine will be switched to a slow speed search mode with the tape path lifted to embrace the

65 head-drum and continue at a slower speed until such

time as the particular track identification code is read out from a track B2, when the machine will stop with the required data track aligned with the sweeping head of the head-drum. To achieve the identification

70 of a very large number of data tracks (e.g. up to five million data tracks) the coded identification must be accurate and recognisable but exceedingly short in duration, and therefore the preferred embodiment employs a separate track for the individual data track

75 codes in addition to the group identification track. Indeed, in some cases it might be advantageous to employ a plurality of individual data track identification coded signal paths laid side-by-side along the control track B and/or possibly on the control track C, since by increasing the number of tracks the available duration for a given signal is increased as will be readily apparent. It is anticipated that the carrier T will have a width t of $1/2''$, and the width of a data track will be 49μ . Before turning to details of the

80 preferred coding of the control signals it should perhaps be stated for the sake of clarity that the essential format of the tracks corresponds closely to that of a video recording, although in normal use for data storage the recording is made with the tape stationary and therefore the track will automatically be correctly read-out when a stationary tape playback mode is employed. However, it would be possible to arrange for the recording of successive fields of a video signal with the tape moving in the

85 conventional manner if such a facility should be required, and in such a case controlling could be used in known manner to record or replay the frames of a video-signal, including the use of a four-head drum to improve a "still-frame" facility, if desired. However, this is not the intended main field of use, and the data carrier will normally be used with the individual data tracks recorded in the stationary tape mode. For this reason it is proposed that in a preferred embodiment of the data carrier

90 the track identification signals may be pre-recorded on one or more paths to provide for group identification if necessary, and to provide for the one or more data track identification code signal paths. With such a pre-recorded control signal it is only necessary to

95 insert the tape carrier in recording apparatus and run the tape for an initial number of tracks in order to insert synchronisation pulses at the requisite points indicated by the pre-recorded control signals, so that the normal servo system control can come into

100 operation. It is anticipated that when a data carrier is intended to hold a large quantity of pre-determined data the initial data tracks can be used to contain a detailed index giving the location of the particular items of data under some form of key word and the micro-processor which forms an intelligent controller for the apparatus can then be used to read-out the index into memory, and then serve to move directly at high speed mode to reach the required data track in the main body of the store. As a further refinement

105 it is possible to utilise at least one audio signal path on one of the longitudinally extending control paths, which would enable key words to be entered for the coarse identification of a block of stored data, and/or for use in recording video sound in apparatus that

110 has been adapted to replay such video signal with a

115

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125

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moving tape carrier.

The preferred form of identification code will now be described with reference to the set of waveforms shown in Figure 2. It will be understood that various forms of coding can be utilised, but the code to be described, which is termed a tri-phase code, incorporates a number of safety measures to ensure that an accurate identity is read out during high speed wind in either direction, and that the required start of track point is accurately defined. The code also incorporates provision to indicate to the "intelligent controller" formed by a standard micro-processor, that the particular sections of each coded signal are detectable to play their own individual roles in guiding the controller to respond.

Figure 2(a) shows the basic waveform in which the individual elements are of predetermined duration, and may have any one of three potential levels. Preferably the intermediate level is zero, so that one binary state can be indicated by a positive pulse and the other binary state indicated by a negative pulse. The pulse periods are determined by clocks in the controller, and the central level (a zero voltage signal in the present preferred embodiment) will be referred to as an X signal to serve both as a form of parity checking and as a flag marking for the particular sections of a code sequence. Thus in Figure 2(a) we have a basic representation of the possibilities formed by a check signal, followed by a binary 1 signal, followed by a binary 0 signal, followed by a check signal. In the proposed apparatus, in order to ensure recognition of the signals when reading at high speed mode, this particular combination is not used but the simplified figure serves to lead into a description of Figure 2(b) which constitutes the "start of track" signal. It will be seen that the duration of the individual pulses has been trebled to facilitate read-out when the tape is being fed at high speed mode and the combination comprises three check periods, followed by three "1" state signals, followed by three check signals, followed by three "0" state signals, followed by three check state signals. This signal is intended to represent the precise point on the tape at which the tape feed must be stopped in order to read the required data track. Figure 2(c) shows a combination in which two check signals are followed by two "0" state signals, which are followed by two check signals and two "1" state signals, with a final two check signals. Thus this combination is a mirror image of the "start of track" signal but is shorter in duration and is used to indicate to the control computer that the following sequence of signals will be the actual track identification code and we will term this sequence the "start of code" sequence.

Figure 2(d) shows by way of example a typical code track numbering, each four bit pulse being preceded and followed by a pair of check signals, and in the illustrated example there are five pulse sequences comprising four "1" state signals followed by a final signal in which there are three "1" state signals immediately followed by a "0" state. We will assume that this represents the identity of the first track in the sequence, and in order to ensure that the control computer receives the identity correctly

when the tape is moving in one direction or in the other direction this entire sequence is now repeated in reverse order and is followed by an "end of code" sequence in reverse order to that shown in Figure 2(c), and that in turn is followed by an "end of track" sequence which is in the reverse order to that shown in Figure 2(b). With this type of check sequence to separate the sections of the code signal it will be seen that the end of one sequence and the beginning of the next results in there being a unique combination of six check signals, whilst the point separating the end of the "start of track" signal and the beginning of the "start of code" signal is identified by a unique combination of five check signals, which appears in mirror image fashion between the "end of code" signal and the "end of track" signal. A further unique combination comprising four check signals in sequence appears at the centre of the identification track signals and at each end of the identification sequence, that is to say between the end of the "start of code" signal and the beginning of the code identification, and at the end of the code identification and the commencing of the end of code signal. Finally there is the recognisable combination of two check signals which appears between each coded digit in the identification signal itself, and at the centre of the "start of code" signal and the middle of the "end of code" signal. The presence of these unique combinations enables the microprocessor to analyse the identification signals in a clear manner during high speed wind or re-wind, and for simplicity, in the present embodiment, when the controller recognises that it is approaching the group of tracks including the required data track and a slow speed mode is initiated, the coding on the one or more individual track identification paths is formed in like manner.

Figure 3 shows details of the mechanical and electrical arrangement for a dedicated playback apparatus which is an apparatus that will be used in cases where it is essential or highly desirable that there can be no accidental erasure or re-recording of data, and such apparatus may be used for example in a library situation where the vast amount of data stored can be rapidly accessed using the deposit of indexing data in the initial data tracks so that any inserted data store can be initially played to enter the index information in the control micro-processor storage array, and the operator can then indicate by normal instruction entries the particular data track required to be displayed upon a local visual display unit, or to be transmitted to a remote source, or to be used in whatever computer system or communication system that is utilising the data store. The control apparatus includes a storage facility to indicate to the intelligent controller unit the position of the tape at any instant. When an operator inserts an instruction command that leads to a request to have access to a particular data track, he or she inserts the appropriate command which identifies the address, either directly or via a programme, possibly after reference to the index, and the circuitry within the micro-processor determines whether it is necessary to go into a high speed mode in one direction or the other and initiates this mode if

necessary. When the appropriate group identification signal is located, assuming such group identity is a feature of the particular system, the apparatus switches to a slow speed mode to lock onto the particular required data track. For this purpose the apparatus is such that high speed winding is not affected directly from reel to reel, but the track path is taken via a code head, and there is a pinch wheel on the track path together with lefthand and righthand torque tension sensors to indicate to torque comparison amplifiers the track tension and facilitate rapid response when a required identification signal is read out. When the group identity is found the apparatus switches to the slow mode which causes two guide arms GA to lift the tape up and around a head-drum so that the tape adopts a helical path about the head-drum and is approximately 180° around the drum surface. There is a pre-tension guide arm which cooperates with the forward and reverse pinch caps to give precise servo control of the tape position. The control head is intended to detect the pulse at the beginning of the recorded data track and stop the tape in order that the head/drum can read out the data track. The initial portion of each data track contains the track identification code number, or reference in index or programme routine, and this is compared with the required track identity in the controller to ensure that the apparatus is operated correctly. Should there not be correlation between the required identity and the track pulse that is being scanned the scan will continue without read out display until the end of track pulse which forms part of the data track is reached, when the controller will automatically cause the servo to re-adjust the tape position in the direction indicated by the error between the data track identities. Thus, assuming the control head has fed a signal to the amplifier to supply the control circuit with a signal showing that it has located the correct address code that has been requested by an operator, the lefthand and righthand torque tension motors will stop and the forward and reverse motor will lock in. The head-drum will now sample the data to check the identity of the track number against that of the control track sequence, and can immediately cause further tape feed if there is not identity. Alternatively, as mentioned above the data read out can be suppressed and the track sweep completed to be terminated by the "end of track" signal which is itself recorded on the data track. Should fine adjustment be required the pre-tension guide arm PTA will operate in one direction or the other to draw the tape further or allow the tape to be drawn back in order to obtain the precise alignment of the data track with the heads on the head-drum. The lefthand torque tension motor will have been controlled by the apparatus to indicate the precise tension of the tape and the guide arm GA and maintain that tension with respect to the pinch wheel FR. Whilst in this condition the righthand torque tension motor is set to give sufficient torque to avoid there being any slack tape between the cassette and the pinch wheel. Thus, if the required address is some distance away the guide arms GA will be in their respective positions A so that the tape is passing the control

track code reading head or heads, and high speed winding can be continued until the approach of the required identity track indicates to the control computer that it is time to convert to the slow speed mode, when the guide arms GA will move the tape to the respective positions B indicated schematically in Figure 3.

Figure 4 shows in schematic form the additional apparatus that is provided for a complete recorder and feed out device. The mechanical arrangements have already been described with reference to Figure 3 and it only remains necessary to consider the additional circuitry that is required to provide for recording. When a recording function is required a new tape is inserted and the code head will record onto the tape a number of synchronising pulses as it reads the pre-recorded track identity code sequences. In some cases it may be considered more desirable to initially record the track identity code signals via the apparatus but present experience suggests that more reliable and consistent results will be obtained if these tracks are in fact pre-recorded. An initial coding signal may be inserted to indicate the total number of data tracks that can be recorded onto the particular tape.

A suitable computer circuit is such as a dedicated controller to control the read, write and erase apparatus, plus logic to automatically drive the apparatus to any required data storage track in either high speed mode or slow speed mode, control being provided for the input and output functions and any other appropriate functions, and/or multi-user bus facilities.

100 CLAIMS

1. A data store in which a rectilinear data carrier is provided with a control track along at least one edge and a plurality of inclined data storage tracks each extending to a respective point adjacent said control track across said data carrier, each said data storage track carrying a signal sequence comprising a start code signal providing a unique track-identification code number, an end of code signal, and any data recorded thereon, and in which said control track carries a sequence of said unique track-identification code signals in numerical order, each preceded by a start-of-track signal and a code start signal, and each followed by an end-of-code signal and an end-of-track signal, the signals in said sequence on said control track being so recorded that they can be read-out by relative movement of said control track with respect to a read-out head in either direction, and said start-of-track signals either being aligned with the start of the related data storage track or spaced from that track by a predetermined distance in a predetermined direction along said control track.

2. A data store as claimed in Claim 1, in which said data-carrier is a flexible tape.

3. A data store as claimed in Claim 1 or Claim 2 in which said data-carrier is of magnetic material.

4. A data store as claimed in any preceding Claim in which said inclined data storage tracks are helically formed.

5. A data store as claimed in any preceding Claim, in which said coded signals are recorded in a tri-phase code.

6. A data store as claimed in any preceding Claim in which said recording data is a video-signal.

7. A data store as claimed in Claim 6, in which said video-signal is recorded as a frequency-modulated signal.

8. A data store as claimed in Claim 7, in which said frequency modulated video-signal has superimposed thereon an amplitude-modulated chroma signal.

9. A data store as claimed in any preceding Claim, in which said control track is a fine-setting control track, and an auxiliary coarse-setting track is provided containing a similar sequence of signals identifying respective groups of said data storage tracks.

10. A data store substantially as described with reference to Figures 1 and 2.

11. Data store read-out apparatus for use with a data store as claimed in any preceding Claim in which drive means are provided to move said data carrier relative to a control track read-out head in such a manner that the signals on said control track are read-out, selection means being provided to request that the data carrier is automatically driven to a required data-storage track, logic means being provided to determine the direction of travel required to reach the required track, said drive means initially causing relatively high-speed mode if required, until further logic means detect the approach of the required track, whereupon a relatively slow-speed mode is initiated by the "start-of-track" signal at said control track read-out head, and said tape is caused to fold about and partly embrace a rotating drum which carries a plurality of data read-out heads positioned to sweep along said required data-storage tracks, and drive means is caused to continue said movement in a relatively slow speed mode until the required track-identification code signal is read-out, when said tape is either held stationary with respect to said control-track read-out head, or moved by drive means at a rate to bring the start of the succeeding data storage track into alignment at the end of sweep of said required track.

12. Data store read-out apparatus as claimed in Claim 11 when dependent upon Claim 9, in which said slow speed mode is initiated by said coarse-setting control track signal, and data read-out initiated by the signals on said fine-setting control track.

13. Data store read-out apparatus as claimed in Claim 11 or Claim 12 when dependent upon Claim 7, in which said drum carries four heads, spaced equally about the drum, and interlaced display of the recorded video data signal is achieved by switching to alternate heads during replay.

14. A data store recording device comprising apparatus as claimed in any one of Claims 11 to 13, in combination with respective erase and recording circuits for connection to said data read-out heads.

15. Data store read-out apparatus substantially as described with reference to Figure 3.

16. A data recording device substantially as described with reference to Figure 4.

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